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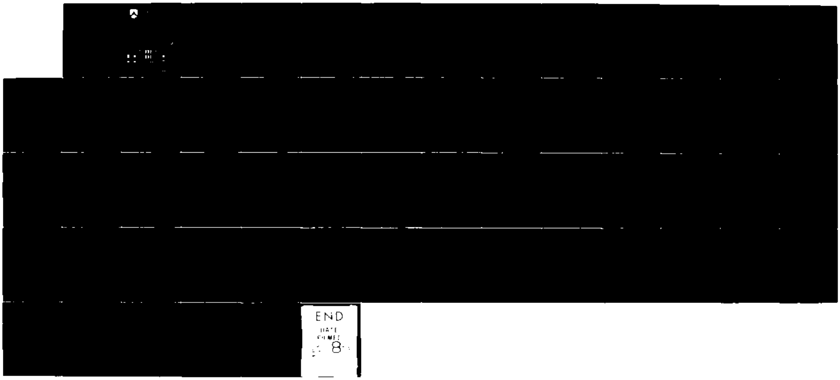

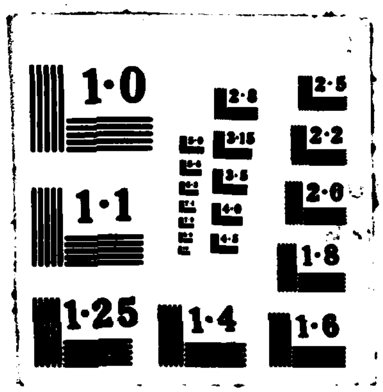
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AIR WAR COLLEGE

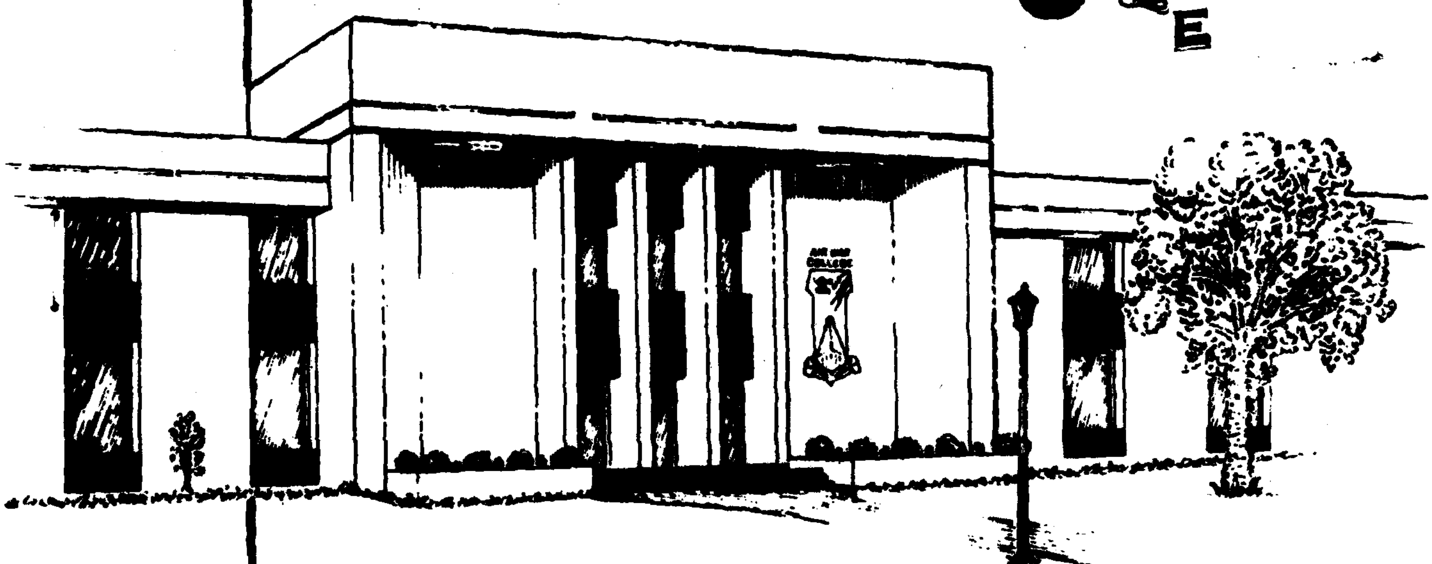
RESEARCH REPORT

No. AU-AWC-87-162

AD-A186 831

THE THREATS TO SURVIVAL IN A NUCLEAR ENVIRONMENT

By LIEUTENANT COLONEL RALPH PASINI



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THE THREATS TO
SURVIVAL IN A NUCLEAR ENVIRONMENT

by

Ralph Pasini
Lieutenant Colonel, USAF

A RESEARCH REPORT SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE RESEARCH

REQUIREMENT

Thesis Advisor: Colonel Bill Moore

MAXWELL AIR FORCE BASE, ALABAMA

May 1987

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AIR WAR COLLEGE RESEARCH REPORT ABSTRACT

TITLE: Survival in a Nuclear Environment

AUTHOR: Ralph Pasini, Lieutenant Colonel, USAF

A description of the primary threats to survival during and after a nuclear attack, focusing on the weapons effects of blast, thermal and short- and long-term radiation. Discussion of simple rules for self-protection from fallout. Discussion of myths, facts, and some philosophy on how to survive a nuclear attack.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Ralph Pasini (MA, Southern Illinois University) has been interested in nuclear survival since 1962 when he first participated in a nuclear shelter construction experiment sponsored by the Oak Ridge National Laboratory and in conjunction with the Atomic Energy Commission. He served with the 46th Heavy Bombardment Squadron (B-52H), Grand Forks AFB, North Dakota, and was Operations Officer and Commander of the 668th Heavy Bombardment Squadron (B-52G), Griffiss Air Force Base, New York. Colonel Pasini also served as a Section Commander and Squadron Commander at the Squadron Officer School, Maxwell Air Force Base, Alabama. He is a graduate of Squadron Officer School, Air Command and Staff College, the National Security Management Course, and the Combined Air Warfare College. Colonel Pasini is a graduate of the Air War College, class of 1987.

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CHAPTER I

INTRODUCTION

The purpose of this paper is to explain, in a very short treatise, the fundamentals of survival in a nuclear environment. In Chapter I, I will give an overview of the paper and discuss the background and antecedents for the establishment of America's civil defense program. In the next part of my paper I will briefly describe: the difference between fission and fusion weapons and how nuclear weapons are used; the nuclear weapons effects, including thermal, blast, and radiation; and the long-term threat to survival--fallout. Chapter II will be the prime focus of the paper. In Chapter III, I will attempt to clear up many of the myths associated with survival in a nuclear environment and how one survives an attack. In the last part of the paper I will summarize and add a few personal comments.

In preparing this paper, I have read more than 20 books and periodicals on the subject of civil defense and nuclear survival. I have studied our Civil Defense program for many years. It continues to be my personal avocation to study the subject of nuclear survival and related topics. As a hobbyist I have built and lived in nuclear shelters for long periods of time. I have first-hand experience with the problems of ventilation, food preservation, sanitation, and the "willingness to survive" in close quarters. I consider myself an expert on the subject of survival in a nuclear environment. Additionally, I have spent more than ten years in the Strategic Air Command flying America's premiere strategic nuclear bomber, the B-52. It is for this reason that I have decided to write about a subject I consider neglected by all segments of our society. Hopefully, this paper will help you to survive.

Background

At the close of World War II, the United States of America was, by any standard of comparison, the most powerful nation on the face of the earth. The United States had harnessed the atom and hastened the victory of the allies over the Axis, developed an economic and political system of unequaled stability, and ushered in a new era of prosperity for its people. America was the sole possessor of the nuclear fission bomb; and as our nuclear arsenal rapidly developed in the late 1940s, the United States was quite secure and comfortable in its ability to defend the homeland.

In consonance with its long tradition of NOT maintaining a large peacetime armed force, the United States went through a tremendous demobilization and withdrew millions of fighting men and women from the Europe and Asian land masses in the post-war years. The Soviet Union, on the other hand, actually consolidated its forces and began a campaign to spread Soviet communism through Central Europe and South Asia. Soviet troops advanced while the allies went home to celebrate victory over the Axis. The United States disregarded warnings from President Charles DeGaulle, Sir Winston Churchill, and General Douglas MacArthur as America immersed itself in "things American." In February of 1945 General MacArthur stated, ". . . further Russian intrusion should be met by force" (1:493).

Russian consolidation of Latvia, Lithuania, and Estonia into the Soviet Empire as well as dismemberment of Poland accelerated the growing gap between East and West. The positioning of large segments of the Red Army in East Germany, Poland, Czechoslovakia, and Hungary, as well as occupation of part of Iran sent shock waves through the West. The Soviets continued to modernize their military and industrial capabilities, almost at a wartime pace. Whole industrial complexes were removed from occupied countries and reassembled in the Soviet Union. Then in 1948 came the Berlin Blockade and the subsequent Berlin Airlift. The Russian desire to perpetuate the goal of a world Marxist Revolution and to, more importantly, confront the American superpower head-on was now manifest.

During the war, many US B-29 and B-17 bombers had made forced landings on Soviet- and Chinese-controlled territory. The Soviets rarely permitted these aircraft that had bombed Japan to depart, probably because the Soviets were not at war with Japan. At least one B-29, the Ramp Tramp, was disassembled and taken to the A. N. Tupolev research facility in July of 1944 (2:60). The B-29 was on the leading edge of reciprocating engine technology in 1944 and could fly higher, faster, and farther than any other bomber aircraft in the world. The Soviets, already with an advanced aircraft industry, copied and improved the B-29; and, in less than one year Tupolev unveiled a new long-range bomber almost identical in appearance to the B-29 (2:160). Now, for the first time in its history, the continental United States could be attacked with long-range bombers from across the sea.

Then, in the late 1940s, a bizarre and as of yet still not completely explained chain of events occurred in which Julius and Ethel Rosenberg and untold other Soviet agents provided America's nuclear secrets to Dr. Andrei Sakharov and his team of Soviet and German physicists. The Soviets very quickly detonated a large atomic bomb, to the surprise and dismay of the entire world. Suddenly, the USSR, a largely agrarian nation of tens-of-millions, was transformed into a nuclear superpower that had to be reckoned with, and a nation that for years to come would be the prime adversary of the United States. The USSR would be a nation that would compete economically, politically, and militarily for world domination.

In the early 1950s, America responded to the military challenge of the Soviet Union. Thousands of air defense aircraft were deployed to protect the continental United States. Nike-Ajax and later Nike-Hercules antiaircraft missile batteries ringed many major US cities. As a high school student in the mid-1960s, I remember quite vividly the numerous Nike-Ajax batteries in the suburbs of Pittsburgh guarding that industrial complex. The high school which I attended was adjacent to one of four Nike batteries in our rural school district, each with 16 missile launchers. The Distant Early Warning Line and Pine Tree Line radars were linked into our long-range defensive network. Picket ships and Texas Towers were used for coastal warning. Offensively, the Strategic Air Command deployed B-36 and later B-47 and B-52 aircraft in large enough numbers to threaten any adversary's cities and industrial might. Jupiter and Thor IRBMs as well as later Atlas and Titan ICBMs became a formidable force for retaliation against any would-be attacker.

In addition, a massive and unprecedented civil defense program was initiated by the United States to educate its citizens on the hazards of nuclear war and, more importantly, to teach its people how to prepare for and survive a nuclear attack. Civil defense would be the final program by which the United States would attempt to deter attack and to survive its population. Radio and television stations nationwide were enlisted to participate in early warning of nuclear attack via CONELRAD stations. Nuclear scientists wrote extensively on subjects including nuclear bomb shelter construction, detection of nuclear radiation, food preservation, water storage, ventilation and heating of bomb shelters, and sanitation in closed environs. America's vocabulary expanded to include words such as alpha, gamma and beta radiation, fission, fusion, neutron, proton, residual radiation, half-life, hydrogen, heavy-water, air burst, ground burst, thermal pulse, electro-magnetic pulse, uranium, plutonium, cesium, strontium, and a myriad of others--words that would have a profound effect on American's life styles for as long as they would live. Thousands of citizens of the United States received personalized training in the "art" of nuclear survival.

The author, as did many Americans, participated in a survival exercise sponsored by the Oak Ridge National Laboratory. In this exercise, high school students were given written instructions and a specified period of time to construct and stock an improvised nuclear bomb shelter. Students then lived in the shelters for periods up to seven days under austere conditions. Most other American school children received nuclear attack training drills--some as basic as moving to school hallways and some as sophisticated as massive relocation to non-populous areas. Prefabricated nuclear shelters for sale along our highways in metropolitan areas were as common as the newly emerging Volkswagen dealerships.

In general, the population of the United States was informed and motivated to learn about and prepare for the unthinkable--nuclear war. The US government-sponsored program was a multi-billion dollar endeavor of enormous scope and proportion. Private citizens enthusiastically invested their time and effort in preparing and stocking personal survival shelters. Community shelters were manned and ready should nuclear attack occur. Most importantly, psychologically, the citizenry were convinced that barring a direct hit, they could survive a nuclear attack. According to Eugene Wigner, author of Survival and the Bomb, ". . . the number of Americans who think that they would have a very good or good chance of surviving increases sharply, and most respondents anticipate living through a thermonuclear war if they were provided with shelter and not directly attacked" (3:36). Hence, it was logical to prepare for an attack, just as one invests in personal insurance policies to provide for children's education in the unlikely eventuality a wage earner should expire at an early age.

In 1987, approximately 35 years after the Soviets detonated their first atomic weapon, the US civil defense program barely survives the annual congressional budget cuts. In 1977, the United States spent less than $.50 per person for civil defense-related matters, while Switzerland, as reported in the November-December issue of Swiss Civil

Defense Magazine, spent $10.85 per citizen on civil defense. The Soviets in 1977 spent between $8.00 and $20.00 per person (4:6). In 1987, the gulf has widened between the United States and the Swiss and Soviets. Staff manning of regional civil defense offices are on a skeleton basis. The large majority of schools do not include in their curriculum material on nuclear civil defense or on nuclear attack evacuation drills. When is the last time you paid attention or even heard a CONELRAD test on your television or radio? I challenge you to find a distributor or builder of nuclear fallout shelters. Most Americans, even those of us who have spent the better part of their lives in the military, are essentially unenlightened on the threat posed by gamma radiation--let alone what measures to take to survive a nuclear exchange between the United States and the Soviet Union. Most importantly, I am convinced the American people no longer believe it possible to survive a nuclear attack. Wigner reports this belief seems to be supported by the result of a recent study, "Substantial proportions of Americans do not, personally, expect to survive a thermonuclear war" (3:36).

Noted lecturers, even government officials, feel obliged to advance the notion that (1) the costs of civil defense would be exorbitant, (2) dollars spent for civil defense would rob from the poor, (3) survival is NOT possible, (4) nuclear war will never occur anyway, (5) a strong civil defense program would mean the United States was preparing for a disarming first strike against the Soviets, and (6) the enemy would direct more of their bombs to kill population centers (4:225-232). Dr. Cresson H. Kearney, author of Nuclear War Survival Skills and the man I consider to be this nation's most renowned expert on nuclear survival, has stated,

> No nation other than the United States has advocated or adopted a strategy that purposely leaves its citizens unprotected hostages to its enemies. The rulers of the Soviet Union continue to prepare the Russians to fight, survive, and win a nuclear war. In contrast, influential Americans continue to demoralize us with exaggerated descriptions of nuclear war. Beginning with President Kennedy, all our Presidents have described nuclear was as "the end of mankind," or the like. This not withstanding, the fact that researchers on the effects of nuclear weapons know that although an all-out nuclear war between Russia and the United States would be the worst catastrophe in history, it would not be the end of mankind or of civilization. Today an all out Soviet attack would result in only about 3% of the area of our country suffering blast and fire damage severe enough to destroy homes and kill most of the occupants! Many millions of unprepared Americans would survive the very wide-spread radiation dangers from fallout and post-attack privations. Tens of millions of additional lives could be saved if even low-cost, realistic preparations were made--especially realistic preparations for evacuating our cities and rapidly building good expedient shelters during a worsening crisis (4:5).

CHAPTER II

THE WEAPON AND ITS EFFECTS

Atomic and hydrogen bombs come in all sizes and shapes. Some have small yields designed to flatten highway bridges and others are large yield weapons that can devastate an entire city. Nuclear weapons are similar to conventional weapons in that they produce blast or shock, and heat or thermal radiation. They are dissimilar in that nuclear weapons also produce prompt and long-term nuclear radiation. The nuclear weapon is an extremely efficient device because so little physical matter is required to create a massive explosion. Colloquially speaking, one obtains "more bang for the buck" from a nuclear device of the same size as a conventional weapon. The great energy produced in an atomic explosion is possible because the splitting of atoms releases enormous energy. Tri-nitrotoluene (TNT) explosives can't break the bonds holding atoms together, hence, cannot release these enormous energies (5:712,713).

An atomic bomb is an extremely complicated device to construct, as recognized by the limited number of nations in the world that have been able to successfully detonate one. For the purposes of this paper, I will give a brief description of the process involved.

There are two primary types of nuclear weapons: fission weapons commonly called atomic bombs and fusion devices commonly called hydrogen bombs. Both are nuclear weapons in that the bombardment of the nuclei release enormous amounts of energy. Prior to constructing a weapon, one must obtain the critical uranium as required. Uranium is currently mined in the United States, USSR, South Africa, Chad, People's Republic of China, and several other nations. In order to make uranium into weapons grade material, it must go through a complex chemical reaction in a nuclear reactor. Both the sources of uranium and the weapons grade conversion process are closely held state secrets maintained under the strictest physical security. No nation wants an enemy to get his hands on the material necessary to build a fission bomb. After the weapons grade uranium or plutonium is produced, it is transferred to the bomb builder.

According to Yegorov and Shlyakhov, two noted Soviet physicists, bomb builders construct bombs in one of two general ways. First, if one obtains enough radioactive material (critical mass), the reaction could begin on its own, since the neutrons in the radioactive material split other atoms and a reaction or explosion can occur. This would be extremely difficult to control if used as a weapon. However, for fission to occur a large amount of uranium or plutonium is required; hence, a very difficult and expensive method of building a bomb. A second method of creating a nuclear explosion is by using a smaller amount of fissionable material (uranium or plutonium) and compressing it instantaneously with an enormous amount of energy, creating the critical mass and subsequent reaction (6:32-38).

Each of the above methods was used in the two very different bombs dropped on Hiroshima and Nagasaki. Both weapons used about 2.2 pounds of material--uranium in the Hiroshima bomb and plutonium in the Nagasaki bomb. No one is quite sure of the exact yields, though ". . .

the Hiroshima bomb is now thought to be in the range of 12-13.5KTS and the Nagasaki bomb is quoted as being 20KT" (7:23).

> The fission process in the Hiroshima bomb began in a manner that is quite simple. The critical mass of uranium or plutonium was divided and placed at opposite ends of a long tube. Behind each half were placed explosive charges that would fire simultaneously, driving the two halves together with great force and initiating the fission reaction that, of course, was over in a fraction of a second. The Nagasaki bomb employed the principle of compression. The isotope was compressed by the simultaneous explosion of a series of TNT charges arranged about it in a hollow shell (8:47).

The major problem with both fission bombs was the safety and handling problems created by the enormous physical size of the devices. In fact, the bomb bays of the B-29s had to be specially modified just to load the weapons (5:749). Additionally, only one weapon could be carried per aircraft. After the war this problem was solved largely through advances in chemical and electrical engineering, miniaturization of components, and a major technological breakthrough--the development of the *hydrogen bomb*.

A fusion or hydrogen bomb uses material such as hydrogen, tritium, or deuterium. Prentiss, in his book Civil Defense in Modern Warfare, says instead of splitting these atoms, they are fused together under the extremely high temperatures created ONLY by a fission reaction (9:148-149). Hence, the name "THERMONUCLEAR" is used to refer to the hydrogen bomb. Each hydrogen bomb is thus initiated by a so-called atomic bomb. According to The Nuclear Survival Handbook it takes a millionth of a second for an H-bomb to explode and reach a temperature of 18 million degrees Fahrenheit producing three to five times the amount of energy per unit weight of material used in the fission bomb (10:1). Hence, most bombs used by advanced nations are probably hydrogen bombs.

They are less expensive to construct, and produce more energy than atomic devices per unit of fissionable material available. However, they are infinitely more complex to construct.

Burst Types

According to Merrill and Severud, nuclear weapons can be categorized into types based on where the bomb is detonated. These types include the air burst, where the fireball does not come in contact with the surface of the earth. In a ground burst, the weapon either detonates on the ground, slightly below the ground, or close enough to the ground for the fireball to touch the surface. A sub-surface or underground explosion is usually conducted in deep shafts or tunnels to comply with provisions of the Limited Test Ban Treaty which bans atmospheric and surface testing (11:55-57). Underwater bursts are presently considered of little military utility and have rarely been used in testing of weapons. Lastly, exoatmospheric or high altitude bursts are used to disrupt communications by producing electro-magnetic pulse (EMP). EMP also destroys unprotected electronic circuity. My focus will be on air and ground bursts because these will be the most commonly used devices in a nuclear exchange.

Fairlamb in his Nuclear Survival Manual states the air burst maximizes the use of thermal energy and minimizes the amount of long-term radiation, since little earth and foreign matter is drawn up into the cloud to later fall to the surface as radiation (12:35). Air bursts are often used on soft targets such as population centers, oil refineries, light industrial facilities, and international border areas where the spread of local radiation products is not desirable. In general, the higher the altitude, the lower the surface effects.

Ground bursts or laydowns, as they are sometimes called, are most suitable when one wishes to maximize blast and shock effects, and to dig a big hole or crater (12:37). Ground bursts are usually selected to destroy buried command and control facilities, tunnels, runways, hard industrial facilities, and the like. Prompt local radiation may be considered a desirable or an undesirable by-product of the ground burst depending on enemy troop concentrations and other factors. However, I believe long-term radiation is always an undesirable by-product of surface material being drawn up the stem into the cloud. It is desirable because the nation detonating the weapon may, in fact, reap the most long-term negative benefits in the form of fallout. This will be discussed in depth later in this text.

Thermal Effects

As I've previously stated, damage from nuclear detonations can be categorized as that resulting from thermal radiation (heat), blast or shock, and both prompt and long-term nuclear radiation. In his classic treatise, Survival Handbook, Suggs has calculated that thermal radiation accounts for about one-third of the total effective output of energy from a nuclear burst and is the first threat to one's survival. "This makes nuclear weapons far more effectively incendiary than TNT bombs, which generate only a small quantity . . . of heat" (8:36). Prentiss states that at the time of detonation, the fireball is in essence a miniature sun, with a temperature of approximately one million degrees centigrade.

This fireball emits ultraviolet rays, that are invisible to the naked eye, as well as infrared rays (9:128). These are the same rays which give us a sunburn. Yegorov and Shlyakhov confirm that thermal radiation travels at the speed of light (186,000 miles per second) in straight lines in a vacuum (6:53). In his book, Suggs does an excellent job of simplifying some complicated physical and scientific principles, and relates that Atomic Energy Commission tests confirm the blast wave tends to retard the advance of a thermal pulse following a detonation (8:37). Therefore, it is possible to see a nuclear flash and still have time to reflexively hit the ground and minimize the thermal damage to one's body. Thermal radiation is deflected by air molecules, dust, fog, and the like reducing their intensity.

> Clouds affect the transmission of thermal radiation. If a burst were to occur above a layer of clouds, the clouds would absorb and reflect much of the heat that would have hit the earth beneath. On the other hand, if a burst occurs below clouds, they may greatly increase the heat given off by the bomb by acting as a mirror and reflecting back to earth the heat that would normally be transmitted upward into the atmosphere (8:40).

In an air burst, the energy is released in all directions to damage and destroy, while much of the ground burst energy is consumed digging the large crater and moving the debris upward. Therefore, thermal radiation is more intense and effective as the altitude of the burst above the target is increased, since the rays have to travel through less atmospheric dust and debris. This is true only up to a point for each size warhead, since at some point, as the altitude of burst increases, the thermal radiation damage to the target will be negligible.

> When the thermal radiation of a nuclear burst strikes any substance, the energy is immediately converted to heat. Because this radiation is so intense and emitted over a short period of time, it is confined to the surface of the object upon which it falls: there is not time for radiation into the surrounding air or absorption within the object itself (8:43).

Light or shiney-colored objects reflect some heat while darker objects absorb or soak up the heat. In fact, "White houses will stand where dark houses burn because white paint reflects up to 90% of heat and light" (13:41). Mawrence and Kimball relate several important points regarding heat conductivity. The amount of damage to an object or person's skin depends upon: (1) the intensity of the heat produced, (2) the type and color of material it falls on, (3) the size of the bomb used, and (4) the exposure of the object (13:40-42). For example, photos of casualties of both the Hiroshima and Nagasaki attacks show second and third degree burns on the side of their face toward the explosion while the other side of their face was basically untouched. Other photographs show human images permanently preserved as shadows on the stone sidewalks and walls, as the body blocked the emitted straight line rays (8:47).

Severud, in The Bomb, Survival and You, states the firestorms that occurred in Hiroshima and Nagasaki were not entirely a result of wooden frame homes burning, but of the contents in the homes catching fire--generally as a result of charcoal burners used for cooking being upset by the blast (11:90). ". . . strange as it may seem, good wood is not easily ignited by heat from a thermonuclear explosion. Wood flames-up when struck by thermal radiation, and chars deeply, but once the heat is past, the flame goes out; ignition cannot be maintained . . ." (8:44-45). However, the contents of a home, including curtains, furniture, and carpet, will ignite and sustain combustion. In both Hiroshima and Nagasaki, residents did have time to escape the firestorms' effects. One interesting fact concerning firestorms is they ". . . actually seem to limit the extent of the fire! Clearly, a fire with 35-40 mph winds rushing at it from all directions is not likely to make very much headway against the wind. Firestorms are, however, very difficult to fight" (8:49).

According to Prentiss, there is NOT a direct proportional relationship between the size of a bomb and the amount of heat radiated. For example, even though a 100 megaton (MT) bomb is ten times larger than a 10 MT bomb, it can only ignite fire kindling a little over twice the distance of a 10 MT device (10:113).

James R. Fairlamb relates that another expected consequence of exposure to thermal radiation is permanent retinal damage to the eye (12:27-28). One should attempt to avoid looking directly at the nuclear flash. An interesting fact is that only several people sustained permanent retinal damage and blindness as a result of the Hiroshima and Nagasaki blasts, though thousands were temporarily blinded. "Nuclear flash may last from 24 seconds with a 1 MT burst to 95 seconds with 20 megatons" (13:41).

The first sign of a nuclear detonation will be the nuclear flash. In some cases, people will have received ample warning, via the national media, to take cover prior to the attack. However, should one be caught unprotected in the open, take cover behind or under anything available. One must act on reflex to place something between oneself and the nuclear explosion. Even though one has already seen the flash, one can still save his life by diving for cover. Fairlamb notes that light travels 186,000 miles per second and blast travels at the speed of sound (about 1100 feet per second), which is significantly slower (12:27,29-30). Therefore, if one has taken cover behind or under a car, the flash has dissipated, and one determines he is far enough from the blast, one should try to move to a basement or culvert to avoid being crushed by flying debris from the blast or shock wave.

In summary, the heat given off by a nuclear burst constitutes the greatest and most widespread IMMEDIATE DANGER to life and property. Suggs suggests three simple rules that can greatly reduce one's probability of injury. First, take cover at the initial flash and one can escape the full effect of the thermal pulse. Second, take cover behind solid objects, in a shadowed area or depression, any place that will protect you from direct exposure. Third, it is possible to leave an area in which a firestorm may be developing (8:49-50).

The Burst Wave

A second threat to survival in a nuclear attack is the blast or shock wave. Deen and Browning, in How to Survive a Nuclear Disaster, state, "It has been determined that a fission weapon exploded in the air at an altitude of less than 40,000 feet converts thirty-five percent of the explosion energy into air shock" (14:23). Suggs relates that just as an air burst, up to a point, enhances thermal effects, so also does it increase blast effects since the blast has less atmosphere to travel through to reach objects on the ground than if it were exploded at the densest point in the atmosphere (8:61). Blast effects include a shock wave, pressure changes, and wind.

The shock wave is the zone of highly compressed air heated to extremely high temperatures that moves in a concentric circle away from the blast site. The shock wave and thermal radiation will travel at the same speed initially, according to Suggs, but as the shock wave moves outward, its speed and pressure decrease due to the resistance encountered in the air (8:53-56). The damage created by the shock wave does not cover anywhere near the area encompassed by the thermal pulse. When the shock wave

> . . . strikes an object, it envelopes it, exerting pressure from all sides over and above normal atmospheric pressure--this is called overpressure. With the shock front goes a strong wind moving AWAY FROM the blast, that tears at any object in its path; this is called the pressure phase. Most damage is done in this phase. Following this there is a gradual decrease in pressure to a normal level, accompanied by a decrease in wind speed. Then the suction phase begins, in which the air surrounding the detonation rushes in to fill the gap in the atmosphere created by the fireball. Wind begins blowing toward the point of detonation (8:52-53).

The length of the cycle from normal-pressure-suction-normal depends on the size of the bomb. Most Americans have seen the classic videotape of an AEC detonation in Nevada, and the resultant shock wave striking a house. The house first is blown one way and then sucked the other. This is, then, the massive "venturi" effect created by the tremendous updraft in the stem of the mushroom cloud and the earlier described pressure changes. According to Suggs, the 20 KT Nagasaki burst pressure cycle from the start to finish was approximately 5 seconds (8:53). In the book Nuclear Attack: Civil Defense, a superb example of the relationship of size of bomb to destructiveness is given.

> The magnitude of the overpressure and its blasting effects increases according to the cube root of the yield ratio between the reference weapon and the new one. For example, the ratio for a one megaton bomb compared with a nominal 20 KT bomb = 50. And the cube root of 50 = 3.68. Therefore, the larger device will create precisely the same overpressure as a smaller one at a range 3.68 times as far (7:35).

There is, therefore, not a direct proportional relationship between size and destructiveness.

Suggs offers another important fact about a nuclear shock wave versus a TNT blast wave. A TNT blast wave exerts pressure on one side of an object, slapping it. The nuclear wave squeezes on all sides at once. The net result is the nuclear shock wave destroys at much lower overpressure than does the TNT explosion (8:53-54). Additionally, blast waves are easily reflected by mountains, large buildings and so on, creating pressures sometimes three to four times greater than the original blast front--in much the same way as the destructive power of a placid river channeled into a gorge is greatly increased. This is called the "Mach Effect." Suggs has tabulated some interesting data collected from US AEC atomic tests. A 20 KT, 100 KT, and 5 MT detonation will exert 3.4 psi, 8 psi, and 100 psi overpressure respectively at 1 mile from ground zero. The 5 MT burst continues to exert 4.8 psi and 1.7 psi out to 5 and 10 miles respectively; while the 100 KT and 20 KT pressure decreases to 0 psi at 5 miles (8:54). These figures are extremely significant when considering wood frame houses and telephone and power lines are totally destroyed at 4 psi overpressure. On the other hand, reinforced concrete buildings such as might be used in large shelters are totally destroyed with approximately 70 psi of overpressure (8:57).

Another closely related agent of blast is wind. Most Americans have witnessed the damage created by tornado and hurricane winds of 100 mph. According to Suggs, winds near the detonation of large nuclear weapons will exceed 1500 mph (8:56). The winds hurl fragments of buildings, vegetation, and animal matter at tremendous velocity. These missiles are deadly. Many of the casualties in both the Hiroshima and Nagasaki explosions were from these projectiles. Additional Atomic Energy Commission data extrapolated by Suggs is quite informative. For example, winds from a 20 KT weapon have been clocked at 115 mph at 1 mile, and less than 40 mph beyond 5 miles from ground zero. For a 100 KT detonation the wind speeds are 240 mph at 1 mile, and still less than 40 mph at 5 miles. For a 5 MT burst, wind speeds have exceeded 1500 mph at 1 mile, 160 mph at 5 miles, 60 mph at 10 miles, and less than 40 mph at 20 miles (8:55).

Blast effects, just like thermal radiation, have a significant impact on structures and personnel close to ground zero. Dr. Cresson H. Kearney notes that in tests conducted by the AEC, combat troops were entrenched within several miles of ground zero and received no significant physical injuries from the blast and heat--this even though protected only by a deep trench (4:207). Although few persons were sheltered during the Hiroshima and Nagasaki attack,

> . . . some people survived uninjured who were far inside tunnel shelters built for conventional air raids and located as close as one-third mile from ground zero. This was true even though these long large shelters lacked blast doors and were deep inside the zone within which all buildings were destroyed (4:13).

By these examples I do not mean to imply that one can easily survive the blast of a nuclear detonation. However, even with minimal protection of the CORRECT kind, the human body is able to withstand the seemingly impossible.

While it is extremely difficult to determine the specific consequences of blast on the unprotected human body, Suggs has deduced several key axioms from the Hiroshima and Nagasaki attacks and tests on animal specimens by the AEC. Very little force is required to do extreme damage to vital organs, especially those in the torso, relatively unprotected by skeletal covering "armor" such as the rib cage. Just as most severe internal injuries in auto accidents occur not when piercing wounds are made but when internal organs are propelled against each other, so also are the kidney, spleen, intestines, bladder, and others forced into the upper body cavity during a nuclear blast, damaging the heart and lungs as well as those organs forced upward (8:61).

As we have already seen, an increase in the yield of a nuclear weapon does not bring about a proportional increase in destructive power. In numerous AEC tests, various types of houses containing basement shelters were subject to nuclear explosions at various ranges. "Even when the houses in which these shelters stood were damaged, the shelters themselves held up; they would have protected their inhabitants from the effects of the blast and further would have been habitable after the blast" (8:59).

I have summarized some rather obvious facts to keep in mind to protect against blast effects to include: (1) take cover whenever possible behind solid objects and remain there until the wind has dissipated; (2) construct shelters in compliance with Civil Defense specifications; these are likely to offer a great deal of protection against blast; (3) remember that the blast wave moves at the speed of sound or approximately 11 miles per minute; therefore, as your distance from a detonation increases, so does your time to take cover. The bottom line is this: prepare a shelter during times of crisis and be prepared to move to it at a moment's notice. Whatever your location, take cover at the first sight of a nuclear flash.

I believe the least understood of all threats to survival from a nuclear detonation is the threat posed by prompt and long-term radiation. Prior to going any further, I'd like to define a technical term. Roentgen (R) is the unit of exposure to gamma radiation. It is interchangeable with "RAD." However, I believe the term "Roentgen (R)" makes more sense when defined in terms of the damage it does to the human body. (See Table I.) It is important to remember the information presented in this table is generic. Deviations can be expected from the norm. This particular table was extracted from Strategy for Survival by Martin and Latham (15:86-87).

Prompt nuclear radiation is, in of itself, not considered the major threat to human life in a nuclear explosion. The reason for this is quite simple. In most cases, anyone close enough to the detonation to receive a prompt fatal dosage of radiation would probably be killed by the blast and thermal effects of the weapon. Those in deeply buried shelters protected from the blast and thermal effects would also be protected from the prompt radiation.

0 - 50 R	No visible effects.
50 - 200 R	Brief periods of nausea on day of exposure. 50% may experience radiation sickness (nausea); 5% may require medical attention; no deaths.
200 - 450 R	Most require medical attention because of serious radiation sickness. Death for 50% within two to four weeks.
450 - 600 R	Serious radiation sickness. 100% require medical attention. Death for more than 50% within one to three weeks.
Over 650 R	Severe radiation sickness. Death for 100% in two weeks.

TABLE I

According to the Survival Handbook, approximately 15 percent of the energies released in a nuclear detonation are released as nuclear radiations. Five percent of this amount is recognized to be "prompt" radiation that occurs within one minute of the burst. The remaining 10 percent is released in the form of "residual" nuclear radiation some time after the detonation (8:63,69). Interestingly enough, scientists do not presently include the energy from prompt and residual radiation in their calculations of TNT equivalent in a nuclear burst. Dean and Browning state,

> The initial nuclear radiation consists mainly of gamma rays, which are electromagnetic radiations of high energy originating in atomic nucleii and neutrons. These radiations, especially gamma rays, can travel great distances through air and can penetrate

> considerable thicknesses of material. Although they can neither be seen nor felt by human beings, except at very high intensities when they cause a tingling sensation, gamma rays and neutrons can produce harmful effects even at considerable distance from their source. Consequently, the initial nuclear radiation is an important aspect of nuclear explosions (14:23-24).

Just as important to understanding the total radiation picture is an understanding of delayed radiation.

> The delayed nuclear radiation arises mainly from the fission products which, in the course of their radioactive decay emit gamma rays . . . and beta rays. The latter are electrons, particles which carry a negative electrical charge and move at a high speed. They are formed by a change in the nucleii of the radioactive atoms. Beta particles, which are also invisible, are much less penetrating than gamma rays, but . . . represent a potential hazard (14:24).

Approximately 200 new substances are created from the split nucleii of the fissionable material in a nuclear detonation (7:39). These are called fission products and additional fusion products are created, many with unstable nucleii that emit radiation for many years. Thus, the fission bomb creates products which are the greatest threat to human and animal life--radioactive fallout.

Initial nuclear radiation damages almost exclusively human beings and other living animal matter. Initial nuclear radiation is a single brief pulse of ionizing radiation released at weapon detonation. Most of what we know about nuclear radiation injury is based on single large dose exposures. This data base is based on the US AEC testing program, and will probably not be expanded to include a combination of multiple large and small dose exposures until there is a protracted war using nuclear weapons. Initial radiation consists primarily of neutrons and gamma rays emitted at the burst site and lasts for about one minute. Suggs relates that while gamma rays move in a line of sight, the neutrons are easily deflected by air molecules and erratically bounce about limiting their effective kill distance (8:85) Initial radiation has considerable penetrating power, with neutrons doing most of the damage near the point of detonation and gamma rays doing the most damage at greater distances.

Neutron particles are much more effective at destroying animal tissue than are gamma rays. Scientists, by varying the construction and materials used in thermonuclear bombs, are able to construct weapons with either more or less gamma or neutron radiation. Hence we can build a neutron bomb that minimizes blast and thermal effects while giving a massive neutron bombardment designed primarily to kill people.

Induced radiation areas are the actual sites where nuclear weapons are detonated and are generally avoided by unprotected personnel.

> Gamma and neutron radiation emitted by a nuclear burst near the earth or on it will cause what is known as induced radiation. The gamma rays and neutrons strike the atoms and molecules of the earth, upsetting their stability and causing them to become radioactive in turn. These atoms will then give off gamma and neutron radiation in the course of returning to a stable state (8:65).

For example, the United States' first A-bomb blast was conducted July 16, 1945 from a steel tower at Alamagordo, New Mexico. According to an article by Robert J. Creagan, the desert floor below the detonation was avoided for years (except for momentary scientific incursions) and was still emitting radioactivity 16 years after the detonation (5:748).

In the discussion that follows I will make no further effort to differentiate between gamma rays and neutron particles; rather, the total radiation and its effects will be discussed. Initial nuclear radiation diminishes very rapidly when compared to other effects from a nuclear detonation such as thermal effect, wind, and overpressure. According to Popkess, the inverse square law applies.

> All forms of radiation decrease in strength in ratio to the square of the distance from their sources. This means that whatever the strength of the radiation at a given distance from where a nuclear weapon explodes, it will only be a quarter of that strength at twice that distance. At three times the distance, the strength of the radiation will have decreased to one-ninth, and so on (10:254).

Additionally, according to tabulated data extracted from Survival Handbook, given a 5 MT surface burst, a nonlethal dose of 150 R would be received at 2 miles from the burst, while 600 mph winds and 25 psi of overpressure would be experienced (8:67). This basically translates that individuals a relatively short distance away will be perfectly safe from initial nuclear radiation, while still in tremendous danger from blast and thermal effects (8:66). Think of it this way--while thermal and blast effects increase, to a point, with height of burst, the impact of initial radiation decreases rapidly with increased blast height.

Gamma radiation, very simply put, is electromagnetic radiation similar to light, radiowaves, and x-rays. It travels with the speed of light and has an effective range of several hundred feet in the air. This is important because while gamma radiation has tremendous penetrating ability close to the detonation, its penetrating ability is rapidly attenuated just a short distance from the source. It takes a considerable thickness of heavy material, such as lead or concrete, to stop this radiation. When gamma rays are absorbed, ions are formed. Exposure to gamma radiation is measured by the amount of ionization produced in the air. The "Geiger Counter" or any suitable ratemeter measures the amount of ionization being given off in any particular area. It is carried about to detect "hot spots" or concentrations of radioactive material. The "dosimeter" is carried by individuals exposed to radiation. It is easily readable and tells the wearer how much radiation he has been exposed to in R's. Gamma radiation is of particular interest because of its capacity to destroy living animal tissue. Deen and Browning state, "Injury is caused by the ionization produced in the body by gamma radiation" (14:41). In broad terms, ionizing radiation acts more like cumulative chemical poisons rather than physical causes of injury such as blast, missiles, and thermal radiation. Like chemicals, large single doses can cause severe sickness or death, depending upon the size of the dose and individual susceptibility. On the other hand, small daily doses can be incurred over extended periods of time without causing illness. Delayed consequences, however, may become apparent in later life (14:41). The short-term effects of radiation exposure are reasonably predictable. It must be understood that different species and different people have different radiation tolerance levels. No one knows why this is the case, though theories abound. The most popular concept is that healthier people tend to resist the devastating effects of radiation better than others (10:17).

No special clothing can protect people against gamma radiation. One may recall pictures of the Three Mile Island cleanup and the white suits and respirators being worn by the workers. Based on my experience, the white "painter's" uniforms were most surely worn to protect against alpha and beta radiation, which will be discussed later. At the present time, according to Popkess, no special drugs or chemicals can protect the body from radiation. However, antibiotics and medicines can be used to fight infection, because the body becomes so weak it is more susceptible to the common infections (10:30-31). Simple precautions will prevent swallowing or inhaling radioactive particles, which are smaller than grains of sand. People do not become radioactive because they have been exposed to nuclear radiation. Radiation sickness is NOT contagious or infectious; therefore, people exposed to radiation are not dangerous to other people. In fact, quite the opposite is true. Resistance is lowered in people exposed to large doses of radiation and they should avoid other persons so they do not contract an illness.

According to Martin and Latham, beta radiation is much less penetrating than gamma rays. Although these rays do travel at the speed of light, they are generally expended in air within ten feet of their source and within a second of their production in a nuclear burst (15:116). Heavy clothing will easily block damage by beta radiation. Again, beta radiation cannot be seen, touched, or smelled. They are not particles, as some sources report; hence, I have intentionally avoided calling them by that term.

A third type of nuclear radiation is alpha radiation. Alpha rays are emitted from the leftover material not consumed in the fission/fusion reaction. Suggs indicates that alpha rays are stopped by the human skin and only become a consequence in the wreckage of an unexploded nuclear weapon, where fissionable material is spread about (8:66).

Now that we have defined critical terms and discussed both initial radiation and induced radiation resulting from the detonation of the weapon, I will shift to the discussion of fallout, or long-term radiation, which poses special problems.

Suggs states that approximately 10% of the total energy release of a nuclear weapon is in the form of residual nuclear radiation. "Despite the fact that this type of radiation represents one-tenth of the total energy release of the weapon, the way in which it is dispersed and emitted is such that . . . fallout represents the greatest threat to human life and welfare. . ." (8:68-69).

The surface bursting of a nuclear weapon creates an enormous crater, the contents of which are vaporized and drawn-up into the fireball and mushroom cloud. Martin and Latham calculate that a 5 MT surface burst will draw as much as 2 million tons of surface material up the chimney or stem of the cloud (15:76-78). Of course, this will depend upon the kind of soil the weapon is detonated in. As this material cools, it slowly begins to fall from the cloud. Fallout particles range in size from several microns to several thousand microns. As a standard of comparison, a dime is 1000 microns thick and a human hair is 100 microns thick. Heavier particles, of course, fall out first. It just so happens that these heavier particles that resemble particles of crushed glass contain most of the radioactivity of the explosion, according to Martin and Latham. The smaller and lighter particles contain trace elements of Strontium-90, Cesium-137, Iodine-131, Plutonium-238, and others.

They are carried to the upper atmosphere and will slowly fall to earth over the intervening days, months, and even years (15:87, 105-106).

The mushroom cloud itself carries the crushed material from the earth's surface, which is drawn up the stem much like a chimney conducts the flame and heat away from a rapid burning fire. The mushroom cloud takes on its characteristic appearance for the following reason: the immense heat carries the fireball and resultant mushroom cloud airborne, just as a balloon rises. The lower atmosphere or troposphere is marked by a uniform decrease in temperature as one goes higher--hence the fireball and cloud, being hotter, continue to rise. However, the stratosphere is characterized by a slow rising in temperature as altitude increases. This is where the cloud loses its buoyancy, flattens out, and gives its characteristic mushroom appearance. According to Deen and Browning, the stem of any given nuclear explosion is generally one-fifth the diameter of the mushroom cloud. For example, a 1 MT surface burst will have a diameter of 20 miles and a height of 13 miles; the stem will be approximately 4 miles wide (14:51).

As the stratospheric winds push against the mushroom cloud, it begins to move. This is obviously not a uniform movement since at various levels of the atmosphere the wind speeds are different (15:113-114). The deposit of radioactive materials commences shortly after the detonation and is concentrated downwind of the target complex in a characteristic elongated cigar-shaped pattern (16:26-27). Also, various weather patterns may move the cloud in different directions than normally expected. For example, it is common knowledge that even though the predominant winds over western Russia are west to east, a great deal of radioactive debris from Chernobyl was deposited over places as far north as Sweden and as far south and west as Italy and France.

Scientists have studied radiation fallout patterns extensively. Realistic mathematical models have been developed to help measure the rate of radioactive decay in fallout. For the purposes of this discussion, I will try to simplify their findings. According to Suggs, the most important finding is what is called the "7/10 rule." "This rule states that TOTAL radiation fallout will decrease by a factor of 10 for every seven fold increase in time after a nuclear blast" (8:73). Let's look at an example where seven hours after a series of large detonations, the radiation rate is 3000 R/hr. for a given point near the detonation. This is an extremely high level but will serve to demonstrate my point. At 49 hours the rate will decrease to 300 R/hr. and at 343 hours (about two weeks) the rate will decrease to 30 R/hr., and in 2,401 hours or 14 weeks, the rate will shrink to 3 R/hr. This is why, in all but the most extreme cases, as noted above, it is generally safe to emerge from fallout shelters at the 2-week point--even though your stay outside should be kept to a minimum.

As I stated earlier, more than 200 different types of radioactive "isotopes" will be clinging to the lighter glass-like debris or fallout particles. Each of these isotopes emits rays at a different rate, each attempting to return to a stable state. This process is called "decay," and as these particles decay, they give off less and less radiation until over a long period of time the radioactivity disappears completely. "The decay of fallout-borne radioactive isotopes is a natural process; it cannot be stopped or reversed" (8:74). However, this should not be confused with the fact that heavy rains, snows, or other atmospheric phenomena can flush out a significant portion of the radioactive particles, causing them to deposit nonuniformly and create hot spots of nuclear radiation on the earth's surface.

The lighter fallout particles characteristically are carried to the top of the mushroom cloud and attract the fission products with long half-lives. The 1976 American Heritage Dictionary of the English Language defines the half-life of a radioactive substance as the time it takes for it to lose 50% of this radioactivity (17:594). Radioactive substances with long half-lives are dangerous because these elements can remain radioactive for thousands of years. Those with short lives are dangerous because they enter the food chain very rapidly. Hence, particles contaminated with Strontium-90 (HL=28 years), Iodine-131 (HL=8.1 days), Cesium-137 (HL=30 years), and Plutonium (HL=24,000 years) create unique problems (5:753). Briefly,

> The greatest hazard from this fallout arises from Iodine-131, which has a half-life of eight days; it would thus take about four weeks for its activity to decrease ten-fold. The main route of Iodine-131 into the body is via milk from cows which grazed on contaminated fields. The route from bomb to atmosphere, to grass, to cow, to milk, to man, is very fast. Milk with a significantly high concentration of radioactive iodine was detected thousands of kilometers from nuclear test explosions (18:33).

Popkess indicates that potassium iodide pills administered to persons living in contaminated areas will reduce the incidence of thyroid cancer (10:31).

In the book Nuclear Winter, Mark Harwell states,

> The main hazard from the long-delayed fallout is due to Strontium-90 and Cesium-137. Their half-lives are so long that the delay in deposition decreases their activity very little. These elements are of concern because they may be incorporated in various organs of the body; strontium accumulates in bone, and cesium is taken up by soft tissue. The beta-rays and gamma rays emitted from them can deliver considerable internal doses. Their incorporation into the human body follows a complicated biological chain from soil to plants, to animals to man. Strontium-90 reaches man mainly through milk and wheat, while Cesium-137 enters through fish, vegetables and other plants (18:33).

It is to the advantage of all nuclear powers to pass along technological advances in bomb production aimed at "cleaning-up" the long-term fission by-products just mentioned. It is possible to construct bombs that greatly reduce these food-chain modifiers like Strontium-90 and Cesium-137. Both superpowers have demonstrated "clean" hydrogen bomb detonations (15:105). The important fact to remember is that radiation does not permanently poison the air. It's decay rate is highly predictable.

According to Suggs, "If the conditions are ideal for fallout deposition, with the wind blowing in a single direction, no winds near the surface, and the terrain fairly level, fallout would be deposited in an elongated cigar-shaped pattern stretching far downwind from a nuclear burst" (8:75). Suggs further suggests a fallout threat is recognized at a dose rate of 0.5 R/hr. Shortly before the time of fallout cessation, the peak dose rate in any particular area will be recorded. The intensity continues to rapidly reduce after this time.

Volcanic eruptions and the distribution of volcanic ash mirror the "fallout" deposition from nuclear detonations. Studying the Mount

St. Helens 50 megaton equivalent eruption and other similar eruptions has significantly added to our knowledge about fallout deposition, mainly because extensive data could be collected without the threat of radiological contamination. Fallout can be readily seen with the naked eye, even when deposited in small amounts of one to three grams per square foot of surface area. The first sensation when fallout begins to fall is the impact of particles on the body similar to that feeling experienced when very fine hail particles fall. The second characteristic sensation is the gritty feeling on the lips and teeth. As mentioned earlier, although particles are generally too large to enter through the nose, they readily collect in the hair, in blouse pockets, pants cuffs, etc. Dry clothing can be easily shaken out, brushed off, or vacuumed to remove fallout particles. However, damp clothing makes removal extremely difficult. Shaking removes fallout particles thoroughly and should be followed by wearing clean, uncontaminated clothing. Under most conditions, fallout should generally be visible. The correct use of "dosimeters" to calculate personal radiation exposure and Geiger Counter type devices, when available, to measure area radiation rates are the best means of controlling radiation exposure. In the absence of these devices, one should "hole up" for at least two weeks.

Fallout is arbitrarily broken down into two categories: (1) "local" or "early" fallout is that which falls within 24 hours of the detonation, and (2) "global," "delayed," or "worldwide" fallout is that which falls to earth after 24 hours (8:72). This is an arbitrary distinction generally accepted by the scientific community to standardize terminology. Approximately 80% of the total radioactivity is contained in the early fallout (8:72).

Immediately following the nuclear blast, your primary consideration is to find shelter that will protect you from the enormous levels of radioactive fallout that will begin. It is commonly accepted that you will have 30 minutes between detonation and the beginning of fallout. If you are fortunate enough to possess a Geiger Counter or personal dosimeter and a preplanned fallout shelter, you are already in a good position to survive. If you have not prepared a shelter, you can still survive.

Time, Distance, Shielding

Protection from radioactive fallout is enhanced by a thorough understanding of the concepts of TIME, DISTANCE, and SHIELDING. I have already touched lightly on these three interrelated concepts, but I'd like to expand a little on each.

TIME: As enumerated earlier, if one is in an area exposed to a constant level of 400 R/hr., and one is there for two hours, he will receive a cumulative dosage of 800 Roentgens. According to Table I, this will be fatal for 100% of the population within two weeks. That is simple enough. But one must also remember our "7/10 rule" previously discussed. For every seven-fold increase in time, the effective radiation level output will be cut ten-fold. If one understands this completely, one's chance of survival is greatly enhanced.

I have written a small scenario which I think illustrates how an understanding of the "7/10 rule" and some of the other principles in this paper can save your life. For example, assume you are driving home from work when a nuclear detonation occurs. Let's also assume you are far enough away to survive the blast and thermal effects as well as the prompt nuclear radiation. You see a large drainage culvert that runs beneath the interstate highway and you crawl into it. This affords outstanding protection from fallout, but you have no food or water; hence, you cannot stay there forever. You postulate an initial fallout level of 6000 R/hr. You will have to move to another shelter later to obtain water and food to survive, but you must "hole-up" until it is safe to exit and see if transportation or help is available. You know using the "7/10 rule" that seven hours later, the effective intensity will drop to 600 R/hr. Forty-nine hours later, the effective intensity will drop to 60 R/hr. Assuming you have received no initial dosage, you can exit the expedient shelter for two hours to search for food and water or better shelter and receive a minimum dosage at 120 R. The USAF Survival School teaches its students that one can survive easily without food for seven days and without water for at least three days. Understanding the TIME factor can save your life.

DISTANCE is another key factor in the survival equation. If one is exposed to a point source of radiation, moving quickly away from the area will be rather simple and effective. For example, if one had the scattered yet unexploded remains of a hydrogen bomb to deal with, moving several miles away from the point source of radioactivity will ensure NO contamination. A good rule of thumb for point sources is ". . . the intensity is decreased by about one-fourth each time the distance is doubled" (14:74). However, the situation becomes a great deal more complex when the radiation source is spread out--as in fallout. It generally is not feasible in the early stages to move to safer areas, since no one will really be certain of the areas of high and low concentration. The best solution here is probably to take cover and use the other two principles of TIME and SHIELDING to survive.

SHIELDING is the third and most important of the protection factors.

> Shielding is the counter-measure against penetrating external radiation that gives the greatest protection. It is the easiest to use under survival conditions, and therefore, is the most desirable. If shielding is not possible the other precautions must be vigorously employed. The degree of protection they afford is significant and can provide the necessary margin of safety for survival (14:75).

It is widely recognized that the density and thickness of the shielding material make it possible to reduce levels of gamma radiation to a negligible level. It is substantially easier to protect against "fallout" than against "prompt" nuclear radiation, since the energy level in fallout is significantly reduced. As a result, a small amount of shielding material can provide excellent protection against "fallout." The half-value concept of shielding is based on the inherent density of certain materials that can be used to construct a barrier or shelter against radiation. The half-value concept can be illustrated easily. For each .7 inches of steel placed between the source of radiation and the survivor, the intensity in "R" is reduced by one-half. Table II shows some representative half-values of some readily available materials. Data for this table was extracted from <u>You Can Survive the Bomb</u> by Mawrence and Kimball (13:55).

Iron or Steel	.7 inches
Concrete	2.2 inches
Brick	2.0 inches
Dirt	3.3 inches
Ice	6.8 inches
Softwood	8.8 inches
Snow	20.3 inches

TABLE II

Using the above figures, if one were to shield oneself with 9.9 inches of earth, the levels of gamma radiation would be reduced to one/eighth its original value. If the radiation intensity were 6000 R/hr., 9.9 inches of earth would reduce the intensity to 750 R/hr. This is still an unacceptable high level. However, using 39.6 inches or a little more than three feet of dirt would reduce the radiation intensity inside to 3 R/hr. While 3 R/hr. is still a high level, you must realize the 6000 R/hr. level outside of the shelter will decrease according to the "7/10 rule." Therefore, three feet of dirt is more than adequate protection in virtually any conceivable survival situation, because the overall radiation level will rapidly decrease outside the shelter.

While thermal and blast effects present the most immediate threat to survival in a nuclear environment, the greatest threat to long-term survival, and also the least understood of the threats, is that created by radioactive fallout. The key to surviving the long-term effects of radioactive fallout is to find adequate temporary shelter and to know the simple rules discussed earlier that govern fallout propagation. An understanding of the "7/10 rule" and the principles of "Time, Distance, and Shielding" as well as a prudent application of common sense will permit one to survive the radioactive intense environment.

CHAPTER III

MYTHS, MISINFORMATION, AND POORLY UNDERSTOOD FACTS

There is a great deal of misinformation and a number of myths regarding survival in a nuclear environment. Most of the material has been disseminated by well-meaning citizens who simply do not understand what they are talking about. Some of the misinformation is spread by interest groups who continue to profit from the diversion of valuable resources from the United States civil defense program. In the competition for dollars, almost nothing is considered sacred. I do wish to clear up some of the major issues which I feel directly impact on our common understanding of the threats previously discussed.

The first misconception is that NO ONE CAN SURVIVE A NUCLEAR ATTACK. While it is certainly true a nuclear weapon represents the most powerful force yet harnessed by mankind, it is nonetheless an explosion subject to the same laws of physics as all other detonations. A nuclear bomb is, quite simply, just a much larger bomb than the ones we are commonly familiar with. The weapons effects are calculable, with specific kill ranges for the thermal, blast, and radiation effects. According to the United States Hiroshima and Nagasaki Survey Teams, numerous individuals survived the Hiroshima and Nagasaki airbursts at ranges less than one mile from ground zero, the point directly beneath the blast (11:55). Many of these survivors are still living more than 40 years after the blast. Most of the 400 persons in shelters at the time of the Nagasaki explosion survived the attack. Suggs relates that during the US nuclear test program, volunteers emerged unharmed from a blast shelter located directly beneath a nuclear detonation that took place in Nevada (8:14). If a nuclear attack occurred today, I feel reasonably secure in asserting that at least 100 million Americans would die needlessly because of the utter lack of knowledge about the threat and the inadequate self-protection afforded them.

A second popular misconception is that NUCLEAR WEAPONS WILL DESTROY ESSENTIAL LIFE-SUSTAINING VEGETATION AND HAVE PERMANENT GENETIC EFFECTS UPON VICTIMS OF A NUCLEAR ATTACK. It is a fact that new vegetation sprouted in both Hiroshima and Nagasaki within a month of the nuclear detonations. While the physical scarring of human victims from thermal and radiation burns was abominable, A Thirty Year Study of the Survivors of Hiroshima and Nagasaki, published in 1977 by the National Academy of Sciences, revealed that ". . . the incidence of [genetic] abnormalities is no higher among children later conceived by parents who were exposed to radiation during the attacks on Hiroshima and Nagasaki than is the incidence of abnormalities among Japanese children born to unexposed children" (4:14). Now, this is not to say there will never be genetic aberrations in generations following a nuclear attack; but the lack of genetic mutants in the first generation children of survivors is probably the most surprising fact to arise from the post-World War II studies.

A third myth is that ALL FOOD AND WATER SOURCES WOULD BE IRRADIATED AND MADE PERMANENTLY UNUSEABLE. While it is true that food and water exposed to nuclear radiation would be irradiated, this does not suggest the materials would be left unuseable. Food and water in containers will be perfectly fit for consumption after the fallout particles, which are easily seen in most cases, are brushed or washed off. Water and food not protected can be safely used if one complies with the simple rules outlined in Appendix 1. The bottom line is food and water should not constitute the major barrier to short-term survival.

A fourth popular myth is that IT IS USELESS TO BUILD A FALLOUT SHELTER BECAUSE EVERYTHING WILL BE BURNED OR DESTROYED BY BLAST IN AN ALL-OUT NUCLEAR ATTACK. Unless one is unusually lucky or hidden in a substantial nuclear shelter, it is almost a certainty one will be killed if a multi-megaton weapon is detonated and one is in close proximity to that detonation. However, several facts are extremely important to consider. According to this nation's foremost expert on nuclear survival, an all-out attack on the United States by the USSR ". . . would result in only about 3% of the area of our country suffering blast and fire damage severe enough to destroy homes and kill most of the occupants" (4:5). On the other hand, a large 20 MT weapon surface burst would result in ". . . the great majority of homes . . . severely damaged to a distance of 10 to 11 miles from ground zero. Within a roughly circular area of about 350 square miles, homes would be severely damaged or completely destroyed" (4:14). Basically, this means while the destructive power of a nuclear weapon is indeed a force to be reckoned with, it is virtually impossible to destroy the enormous area of the territorial United States. By prudently constructing shelters outside of probable target areas, or by knowing where one is going to go in a serious international crisis, the odds of survival are increased substantially. For example, the heavy industrial metropolis of Pittsburgh, Pennsylvania would be a lucrative target for the Soviet's Strategic Rocket Forces. Casualties would be extremely high in the unsheltered cities around Pittsburgh that lie largely on both sides of three converging rivers. However, I believe that by using prebuilt fallout shelters and by moving the population a mere 60 miles to the less densely populated north, a mere fraction of the population would be casualties. In 1980, John Macy, Director of the US Federal Emergency Management Agency, testified that with effective crisis relocation and adequate blast protection, 30 percent of our population could survive (7:200).

A fifth popular myth regarding survival in a nuclear attack is the belief THERE WILL BE LITTLE OR NO WARNING TO AFFORD PEOPLE THE TIME TO TAKE COVER. There is always the distinct possibility the Soviet Union could strike the United States with a "bolt out of the blue" attack, such as occurred at Pearl Harbor. There are, however, several reasons why I believe this is not likely. First, the Soviets will probably attempt to evacuate expected target areas to save their population. This would easily be recognized and give the United States the "strategic warning" necessary to react. Second, preparations for a nuclear strike in all likelihood will be accompanied by large troop movements and the movement of large naval forces and surface forces. Our nation possesses the technical means necessary to detect this. Thirdly, and most importantly, a Soviet attack would most likely be preceded by an international crisis of sorts. Thus, "strategic warning" of an impending attack should normally be available. Assuming that our National Command Authorities notify the populace, they would be kept informed by an American communication's network second to none in the world. Virtually every American citizen has daily access to late-breaking news. "Tactical warning" of an actual attack, although minimal, would be relayed via the television and radio as well as the CONELRAD network. If we would formulate a plan, America's superb highway transportation system puts us in the enviable position of being able to evacuate our cities expeditiously.

The sixth myth espoused by many responsible persons is THEY WOULD RATHER DIE WITH DIGNITY THAN LIVE IN THE WORLD FOLLOWING A NUCLEAR ATTACK. This surely sounds like a cavalier approach to nuclear war, but one must wonder if the persons who espouse this philosophy would just sit idly by and let their families perish slowly from the long-term effects of fallout, or would they fight to survive? I choose to believe most people would fight to save themselves and their families. It must be remembered that the world has survived other crises considered to be hopeless. For example, the English survived the massive bombing of London and other cities in World War II. The Jews survived the holocaust. The Russians survived Hitler's invasion and Stalin's purge, even though a cumulative total of 40 million people were lost. The Black Death in England claimed 50% of the population, and yet people somehow survived and prospered. Regarding a nuclear attack, Mawrence and Kimball state, "Half of us will survive, not because we tried to save ourselves, but because through sheer luck we will not be where the bomb can kill us.

A 50-50 chance for live whether we earn it or not" (13:10). A noted expert on nuclear survival has written,

> In our eagerness to avoid hard responsibility, we sometimes seem to grasp at any excuse, even the soft, siren song of "certain" death. If you understand the problems of survival in case of attack, and if you make reasonable preparations for yourself and your family, you have an excellent chance for life. The odds vary with your locations, the nature and number of weapons employed and the degree of warning, but under any foreseeable combination, they are heavily in favor on anyone who plans to live (4:10).

Another favorite myth, and one perpetrated by the novel made into the movie "On the Beach" by Nevil Shute, is that PEOPLE WHO RECEIVE HIGH DOSAGES OF RADIATION BECOME RADIOACTIVE AND HENCE WILL CONTAMINATE OTHERS. This is very simply untrue. The only possible way the human body could become a threat to others following contamination would be if enormous amounts of radioactive particles were somehow ingested. Even someone who has received a lethal dosage of radiation cannot pass along his sickness to others. I believe this myth is rooted in recommendations that fallout casualties be removed from fallout shelters as soon as possible after death. The reason for removing the remains was to protect the other occupants of the shelter from disease and pestilence caused by the decaying body, not because it would contaminate others with radioactivity.

An eighth area that is poorly understood is the IMPACT OF ELECTROMAGNETIC PULSE (EMP) ON ELECTRICAL COMPONENTS EXPOSED TO IT. EMP is one of the least understood phenomena resulting from nuclear bursts. Both the United States and the USSR terminated atmospheric testing before they fully understood the ramifications of selectively placed high altitude bursts designed to maximize the effects of EMP.

> An EMP is an intense burst of radio-frequency radiation generated by a nuclear explosion. The strong, quick rising surges of electric current induced by EMP in power transmission lines and long antennas could burn-out most unprotected electrical and electronic equipment (4:20).

EMP, then, will at least temporarily interrupt most signals broadcast by radio and television stations. Unprotected electronic equipment will not work. Vehicles with solid state ignitions probably won't start. However, there is some good news. In the last five years, the United States has begun a conversion to fiber optics for communicating all forms of electrical signals. This is already a proven technology as advertised daily on television. As this technology continues to emerge, electrical equipment will be less and less susceptible to EMP.

I am firmly convinced a little information can be dangerous. However, a thorough understanding of the truth about nuclear survival can make it much easier to survive and prosper. I have tried to clarify some of the major myths and poorly understood facts that contribute to our citizenry's fear of "trying to live" after an attack.

CHAPTER IV

CONCLUSION

The unmatched United States civil defense program of the 1960s has given way to a program that barely survives annual congressional budget cuts. The frenzied pace of civil defense preparedness in the 50s and 60s prepared Americans to face the worst of facts. Today, even the large proportion of members of our armed forces are ill-informed or not informed at all on the subject of nuclear survival. If this nation is to survive a nuclear attack, its citizenry must be INFORMED of the threats to survival in a nuclear attack. I am convinced a significant portion of the US population could survive if there is a short period of preparation for an attack, the information necessary to avoid threats to survival is made available, and they possess the tools readily available to most Americans to improvise nuclear shelters.

If Americans were threatened with a massive plague that could kill 50 percent of its population, I am absolutely certain the President and Congress of the United States would mount an all-out attack. Hospitals and medical centers would go all out to enhance life-sustaining capabilities. Plans would be made to evacuate population centers. The American people could rest assured that every effort would be made to protect their lives and that of their children.

It would likewise seem reasonable that a nation faced with an adversary capable of destroying the majority of its population would take the necessary steps to educate and protect its citizens. Unfortunately, for various reasons that are unimportant here, our nation simply has not been willing to make the monetary investments necessary to educate its population on the threats posed by a nuclear attack. Instead, we continue to rely on a concept rooted in deterrence based on the guarantee of mutual destruction of civilizations. It is, therefore, incumbent upon those persons who are informed on the subject of the nuclear threat to inform others.

In this paper I have discussed a number of issues I feel will better prepare the reader to survive a nuclear attack. An understanding of the basic principles of fission and fusion bombs and how they would be used by an enemy are important concepts. Both emit enormous amounts of energy in the form of heat, blast, and both prompt and long-term nuclear radiation. The common forms of employing these weapons are air and ground bursts--the former being used to maximize blast and thermal effects, while the latter is used to maximize blast and radiation effects. Prompt and residual radiation constitute serious threats to survival. However, the greatest long-term threat is that of nuclear fallout. The best method of protecting oneself from fallout is to understand the concepts of "Time, Distance, Shielding" and the "7/10 Rule."

It is unlikely, in my view, that our national leadership will invest the resources necessary to educate our population. It should be clear, however, that a thorough understanding of the principles spelled out in this paper will greatly enhance your probability of surviving a nuclear attack.

APPENDIX I

SHELTER

1. Underground shelter covered with three feet of earth offers excellent protection. Here are some other good shelters, listed in order of priority:

   a. Caves and tunnels.

   b. Storm or storage shelters.

   c. Culverts and basements.

   d. Abandoned and/or mud buildings.

2. Hills, side of ditches, ravines, and river banks are best if digging is necessary.

3. Cover all skin when exposed to fallout.

TIMETABLE

1. Stay sheltered four to six days after last weapons' delivery. A brief exposure, IF NECESSARY, not to exceed 30 minutes to get water on the third day.

2. On the seventh day, exposure of not more than one hour--IF NECESSARY!

3. On the eighth day, one exposure of not more than one hour--IF NECESSARY!

4. From the ninth through the twelfth day, exposure of two to four hours per day--IF NECESSARY!

5. From the thirteenth day on, normal operation followed by rest in a protected shelter.

6. These times are conservative. If forced to move after one or two days, make sure exposure is no longer than absolutely necessary.

WATER

1. You can survive without water for two to ten days, depending on the level of exertion.
2. Obtain water from the safest sources--filter and purify.
3. Springs, wells, or other underground sources are safest.
4. Streams and rivers will be comparatively free of contamination several days after the last nuclear explosion. If fallout conditions exist, avoid for a minimum of 48 hours after the last explosion.
5. Lakes, pools, and other standing bodies are likely to be heavily contaminated.
6. Snow, from six or more inches below surface, is safe.

FOODS

1. Canned and packaged foods are safe. Wash containers prior to opening.
2. Food stored in cellars is safe, if washed. Anything in closed containers is safe.
3. Potatoes, turnips, carrots, and other plants with edible portions underground first choice. Scrub and remove skins.
4. Bananas, apples, and other fruits plus vegetables with edible portions above ground are second choices. Wash and peel.
5. Plants with rough outer surfaces such as lettuce, dandelions, etc., that cannot be peeled are a last resort.

6. Leafy or young plants should not be eaten if heavy rains occurred during or after fallout period.

7. Eggs are safe, even if laid during fallout period. Do not drink milk!

8. Fish should not be eaten.

9. Animal flesh can be eaten if carefully skinned. Do not allow the meat to contact the outer skin. Discard internal organs and flesh within one-eighth inch of bone or joints.

[Appendix I extracted from Strategic Air Command (SAC) Form 673, May 1983.]

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